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Original Article

IoTs and Mobile Application Using Deep Learning Analytics for Leaf Disease Tracking in Bush Tomatoes

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Abstract - *The research objectives consist of two goals. The first objective is to study, design, and develop a low-bush tomato greenhouse control system. The second objective is to construct a mobile application using deep learning analytics for tracking leaf disease in bush tomatoes. The research data was a study of 400 diseased and normal tomato leaves. Information on tomato leaf diseases studied consisted of six diseases: Early blight, Leaf spot, Leaf blight, Late blight, Leaf mold, and Powdery mildew. The results showed that the developed system can respond effectively to detecting tomato leaf diseases. In addition, the application can perform treatment spraying tasks automatically and manually. From the research results, this research is beneficial and deserves further promotion and development.*

Keywords - *Leaf disease tracking, Internet of Things, Mobile application for Leaf disease, Deep learning, Treatment.*

1. Introduction

Tomatoes are an economic crop of enormous significance and value to Thailand in terms of trade, nutritional value, and health of the Thai people [1], [2]. Tomatoes are an essential source of income for farmers and a staple food for communities worldwide. By 2022, the economic value of Thailand's tomatoes will influence farmers and create overall incentives for agriculture.

The Food and Agriculture Organization (FAO) of the United Nations reported [3] that Thailand's tomato cultivation area has increased, with the area under cultivation being 5,505 hectares in 2012, while in 2019, the area under cultivation is 6,895 hectares, an increase of 20.16 percent. At the same time, the demand for tomatoes in Thailand has greatly increased. In 2012, farmers produced 104,146 tons, while in 2022, they produced 137,325 tons, an increase of 31.86 percent (https://www.fao.org). There is a lot of research that focuses on disease prevention in tomatoes [4], [5], [6], [7].

Essential factors in caring for tomato plants include proper soil preparation, watering, fertilizing, pest control, and disease management. Tomatoes are considered plants susceptible to diseases including leaf spots, velvet mold, black dry disease, powdery mildew, etc. Most diseases that affect tomatoes manifest primarily in the leaves, including thin, small, long oval leaves, large round leaves, pointed leaves, deeply serrated, saw-toothed leaves, and so on. Therefore, if farmers can monitor and manage diseases from tomato leaves, it will effectively treat and prevent disease in tomatoes. To help quickly identify and detect disease in tomato plants, using smartphone cameras and using artificial intelligence to analyse and notice signs of disease are effective options.

Smartphone cameras can be easily and quickly transported and communicated over the internet, making it easier for farmers to inspect a wider area of tomato plants before the disease spreads. Therefore, the research objectives consist of two main points. The first objective is to study, design, and develop a low-bush tomato greenhouse control system. The second objective is to construct a mobile application using deep learning analytics for tracking leaf disease in bush tomatoes.

The research framework has been designed and presented in Figures 1 and 2. The scope of this mobile application research is a project by undergraduate students who want to apply integrated artificial intelligence technology to help farmers in Thailand who wish to learn about growing and caring for bush tomatoes. In addition, the researchers wanted to produce a prototype to assemble a learning process for undergraduate students to be applied in the computer science curriculum of the School of Information and Communication Technology at the University of Phayao.

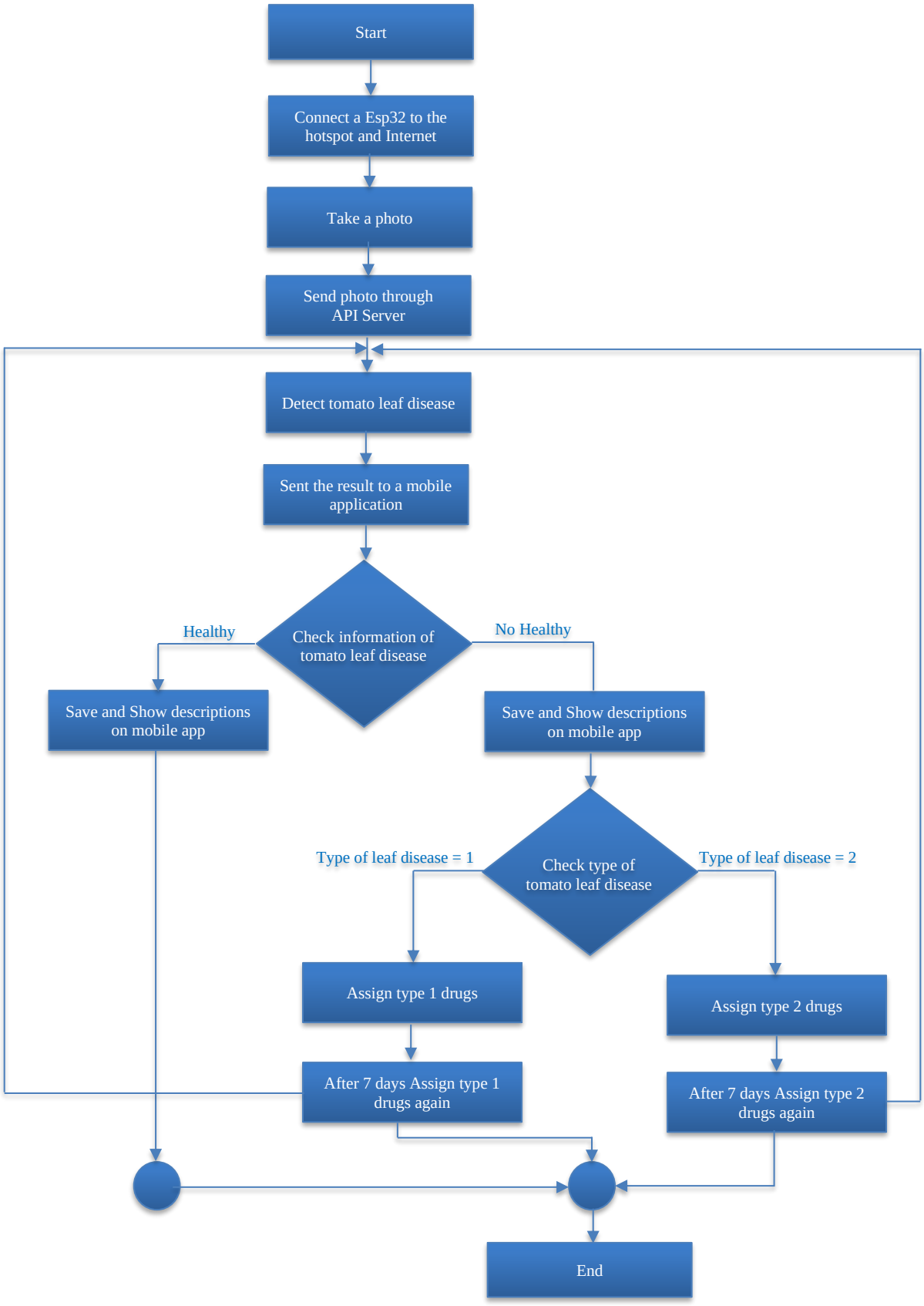

Fig. 1 Flowchart for management and monitoring of leaf diseases in bush tomatoes

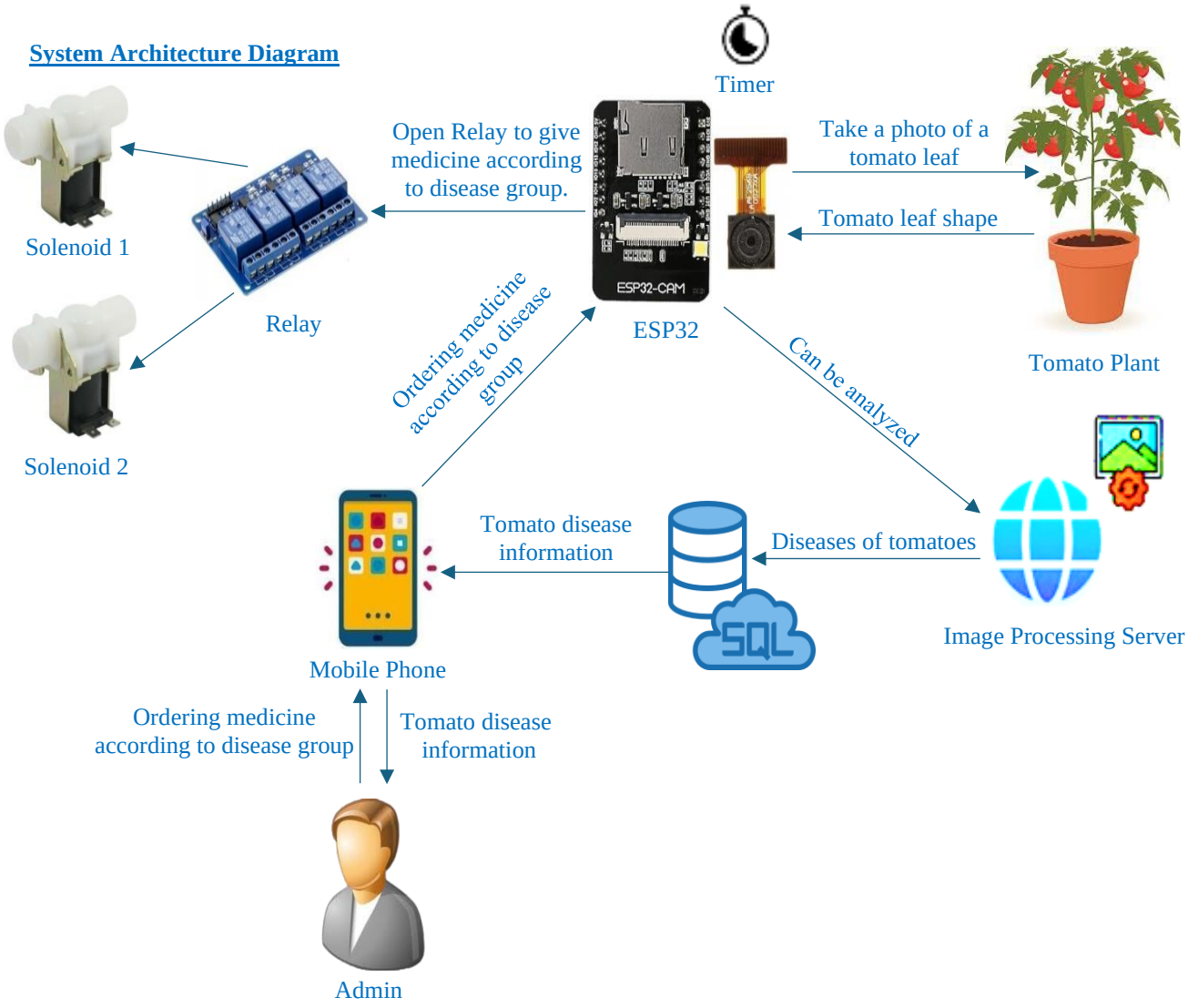

Fig. 2 Diagram for management and monitoring of leaf diseases in bush tomatoes

Therefore, this research is mainly R&D research to create tool prototypes. In addition, bush tomato plants were grown in pots in a controlled location. The equipment used in the research is an internet-connected sensor, so the lab is based in a laboratory at the University of Phayao. Therefore, conducting this research project is primarily a learning process to create knowledge for the students.

2. Materials and Methods

The four main elements outline processes of the Internet of Things (IoTs) and mobile applications using deep learning analytics for leaf disease tracking in bush tomatoes, including 1) a use case diagram, 2) a class diagram, 3) an activity diagram, and 4) entity-relation diagram.

2.1. Use Case Diagram

A use case diagram is a diagram that shows how users of a system work and their relationships with subsystems within the more extensive system. The primary purpose of drawing this diagram is to tell the whole story of the system, whose subsystem consists of a two-stakeholder use case diagram: users and sensors. The users-related use case diagram consists of four use case diagrams, as presented in Figure 3. The first use case diagram shows how the system retrieves tomato types and varieties information. The second use case diagram shows how the system retrieves the disease information and treatment for bush tomato diseases. The third use case diagram shows how the system retrieves disease status information for tomato bushes and disease treatment stages. The fourth use case diagram shows how the system retrieves tomato medicine information and how to use medicine information.

The sensors-related use case diagram consists of four use case diagrams, as presented in Figure 4. The first use case diagram shows how the system captures and records leaf tomatoes.

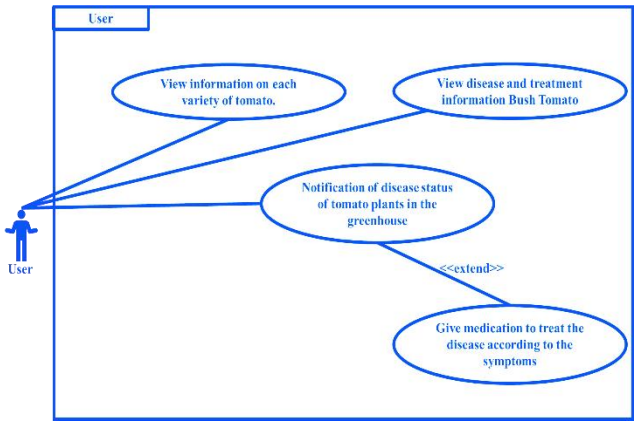

Fig. 3 Users-Related use case diagram

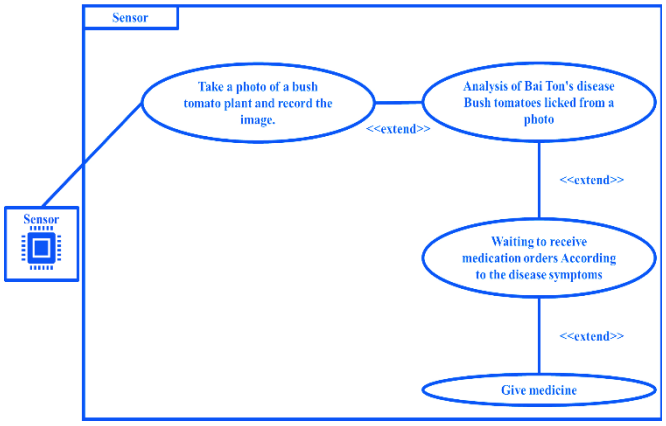

Fig. 4 Sensors-Related use case diagram

The second use case diagram shows how the system analyses tomato leaf disease from images. The third use case diagram shows the system waiting to receive medication orders for tomato diseases. The fourth use case diagram indicates that the system provides medication orders for tomato diseases.

2.2. Class Diagram

A class diagram offers classes and relationships in various aspects between classes in a system. The relationships described in the class diagram are considered static relationships, whereas the relationships that arise due to multiple activities are called activity relationships. The class diagram that this research designed is presented in Figure 5.

2.3. Activity Diagram

An activity diagram is a diagram used to describe activities in the workflow, with each step-in work being called an "Activity Diagram". This research consists of four activities, including an activity diagram for viewing information on tomato varieties, an activity diagram for viewing information on tomato leaf diseases and their care, an activity diagram for notification of the disease status of tomatoes, and an activity diagram for providing treatment medicines according to disease symptoms.

2.4. Entity-Relation Diagram

An entity-relation diagram is a model that describes the structure of a database in a graphical way, which explains the structure and relationships of data consisting of entities. It means the object or thing the research is interested in; attribute, which means the properties of the something of interest; and relations, which means the relationship between entities. An entity-relation diagram of this research is shown in Figure 6.

3. Results

Study and operational results for applying Internet of Things (IoTs) and mobile applications using deep learning analytics for leaf disease tracking in bush tomatoes. Researchers have developed a study laboratory and designed research results that include three main points: results of application analysis and design, results of hardware development, and results of application development.

3.1. Results of Application Analysis and Design

The analysis and application design results can guide and analyse the results of the research operation as follows.

3.1.1. Tomato Bush Disease Analysis

The program can analyse diseases occurring on bush tomato leaves by taking pictures with the ESP32 camera from a bird's eye view. It allows for efficient disease analysis and a clear overview of Bush tomato plants. In addition, analysis of tomato leaf diseases is also a way to check the health of tomato plants to strengthen, prevent, and manage leaf diseases in the plots because they can be grown effectively.

3.1.2. Analysis of Treatment for Tomato Bush Disease

The application can provide information on tomato diseases and how to treat tomato bush disease. The application can control automatic dosing. The application can simplify the care and management of tomato diseases effectively.

3.1.3. Analysis of the Notification System

The application can create agricultural alerts when tomato bush leaf disease is detected. Additionally, it can provide information on the health level status of the tomato plants. Alerts provide tomato growers with a history of tomato management information. It allows farmers to plan and manage future plantings effectively.

3.2. Results of Hardware Development

Development of hardware consisting of a tomato leaf disease detection device and a disease spraying device. The researchers tested tomato leaf disease detection using a model for learning about tomato leaf diseases using high-angle photography with the device. It was found that the equipment could function correctly and efficiently. The testing process consists of three steps. Step 1: Testing with five images of uninfected tomato leaves.

The system can detect normality and does not provide treatment. Step 2: Testing with images of tomato leaves infected with three diseases and ten images of each disease, the system was able to detect abnormalities and provide the correct medicine to treat the disease. Step 3: Testing of medication treatment by the user through an application where the device can work according to instructions. Figure 7 shows the equipment used to spray medicine.

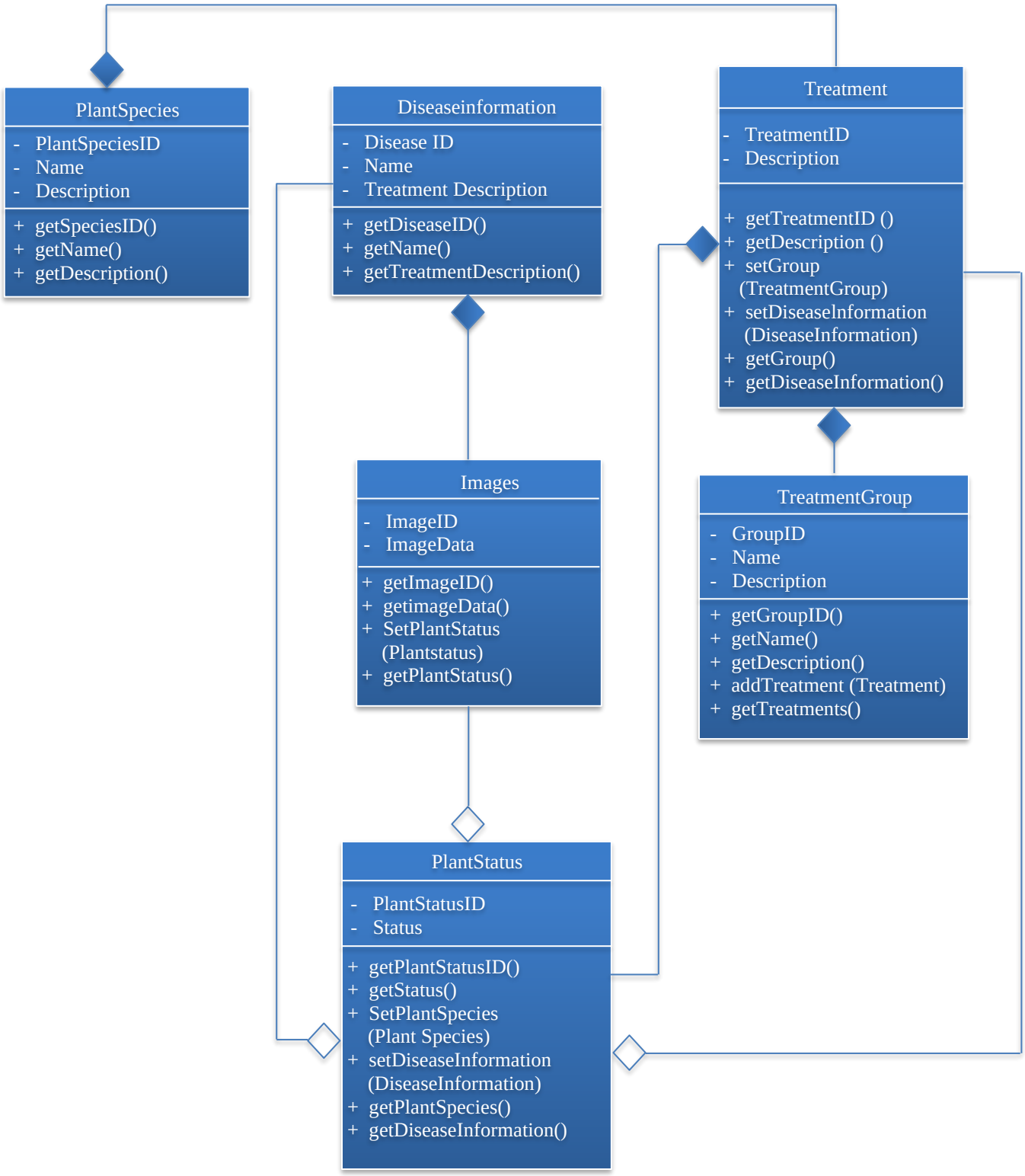

Fig. 5 Class diagrams

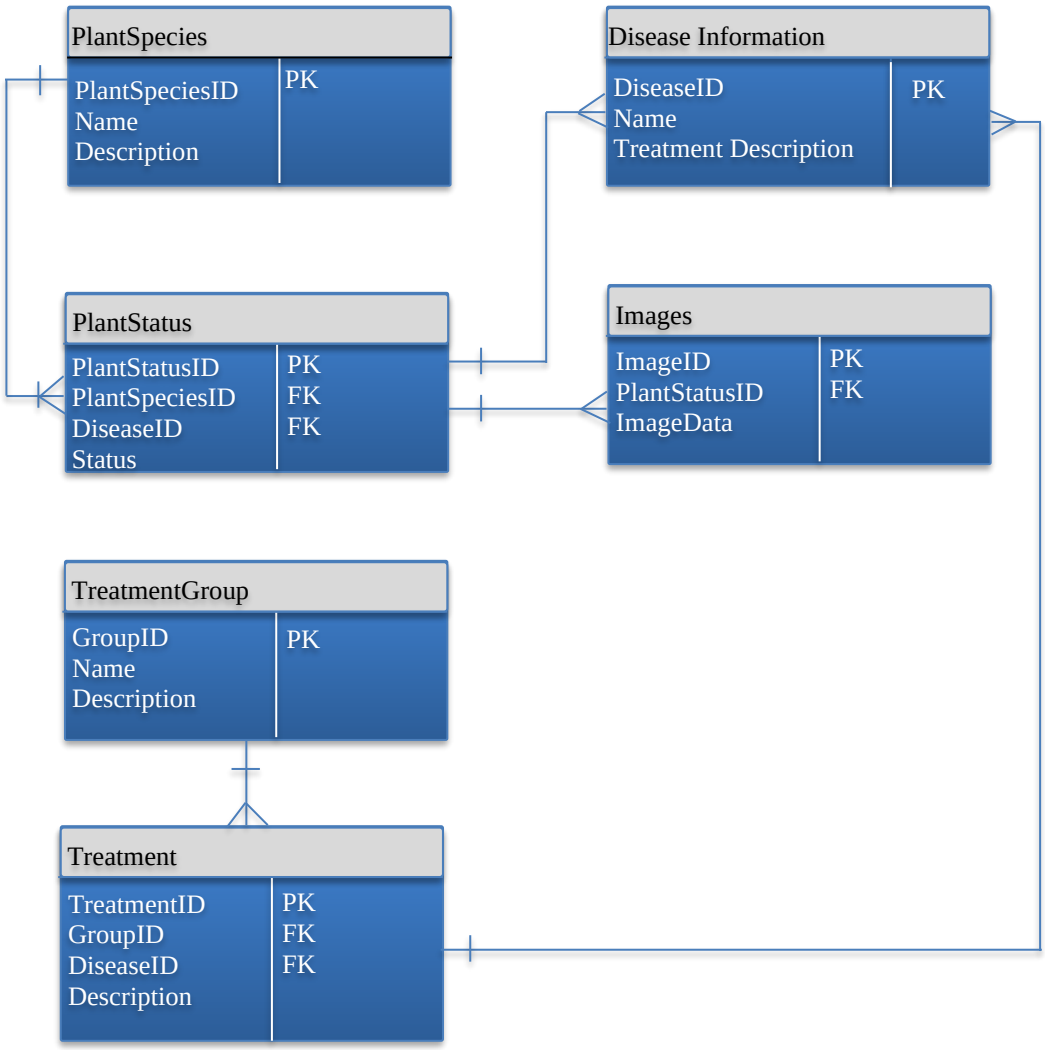

Fig. 6 Entity relationship diagrams

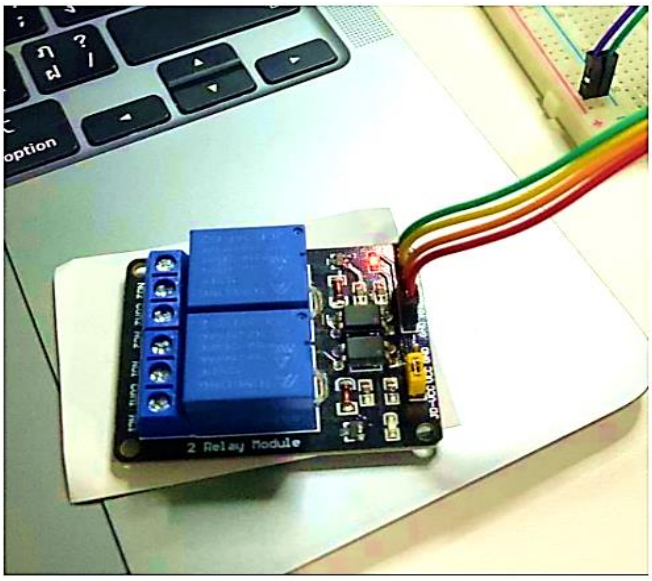

Fig. 7 Equipment used to spray medicine

3.3. Results of Application Development

As a result of developing the application, researchers produced work comprising various components, as shown in Figures 8 to 12.

Fig. 8 Icon and sign in with google

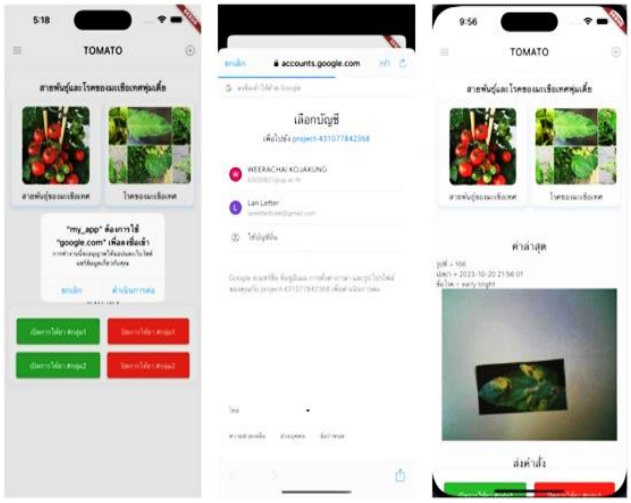

Fig. 9 Authentication for login

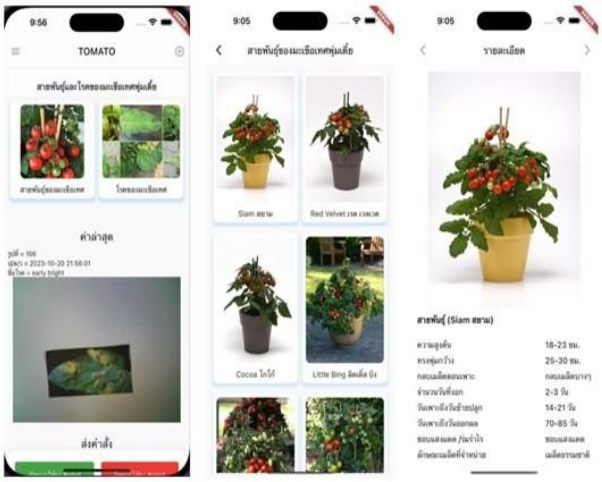

Fig. 10 List tomato species

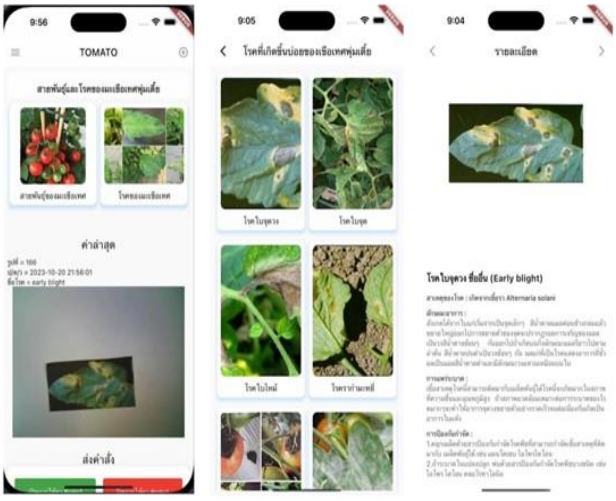

Fig. 11 List of tomato diseases and their treatment

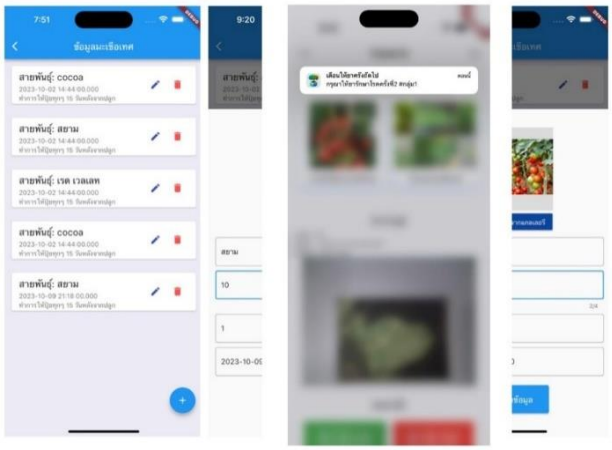

Fig. 12 Notification of the system

4. Discussion

Tomato control and care equipment with IoTs and mobile applications using deep learning analytics for leaf disease tracking in bush tomatoes had been achieved. Devices and applications can work efficiently. It can detect tomato leaf diseases. The system can be operated automatically and manually with efficiency. However, some suggestions regarding this research include: The actual system and operations should be equipped with an efficient network system and a backup power system to prevent unexpected problems. In addition, a comprehensive greenhouse control unit should be designed and built with multiple sensors to obtain accurate signal values.

5. Limitations

The prominent limitations of this research are: This research is a project of undergraduate students, which is a project that encourages students to learn and have experience in doing research. Therefore, in some situations, including data collection, some steps are inaccurate. However, all researchers did their best to achieve all the objectives of this research.

6. Conclusion

The IoTs and mobile applications using deep learning analytics for leaf disease tracking in bush tomatoes have been designed to increase convenience for users in caring for tomatoes. The research concept is to work together between equipment, humans, and data to provide accurate control and maintenance. The research objectives consist of two goals. The first objective is to study, design, and develop a low-bush tomato greenhouse control system. The second objective is to construct a mobile application using deep learning analytics for tracking leaf disease in bush tomatoes. The research framework has been designed and presented in Figure 1 and Figure 2. As a result of the research, the researchers developed an effective device and system for detecting tomato leaf diseases. The research data was a study of 400 diseased and

normal tomato leaves. Information on tomato leaf diseases studied consisted of six diseases: Early blight, Leaf spot, Leaf blight, Late blight, Leaf mold, and Powdery mildew. The results showed that the developed system can respond effectively to detecting tomato leaf diseases. In addition, the application can perform treatment spraying tasks automatically and manually. From the research results, this research is beneficial and deserves further promotion and development.

Acknowledgments

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